NATIONAL BUREAU OF STANDARDS REPORT

5833

PERFORMANCE TESTS OF A TRION HCC
HIGH CAPACITY ELECTRONIC AIR CLEANER
(No. 25 Cell)

by

Thomas W. Watson and Henry E. Robinson

Report to
General Services Administration
Public Buildings Service
Washington 25, D. C.

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Heat Transfer Section
Building Technology Division

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1. INTRODUCTION*

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of electrostatic air cleaners were determined to provide information to assist in the preparation of new air filter specifications.

The test results presented herein were obtained on a specimen electrostatic filter unit submitted by its manufacturer at the request of the Public Buildings Service and included determinations of dust-arresting efficiency with two aerosols (atmospheric air and Cottrell precipitate), pressure drop, dirt load performance characteristics, and cleanability of the specimen.

2. DESCRIPTION OF THE FILTER SPECIMEN

The cleaner was manufactured by Trion, Inc., of McKees Rocks, Pennsylvania, and was of the electrostatic type. It was identified by the manufacturer's representative as a "Trion HCC High Capacity Cell Model 15 with No. 25 Cell." The power pack furnished was a laboratory type pack, Serial No. 7T157, having a variable voltage adjustment to obtain desired settings for the tests. The power pack nameplate data furnished by the manufacturer were as follows:

<u>Type A</u>

60 cycles, 110 volts
Ionizer volts 17.5 kv D.C., Plate 8.7 kv D.C.
Maximum output 24 milliamps

The test unit had a housing with transverse outside dimensions 24 1/2 by 22 1/4 inches and was 23 7/16 inches long. The upstream and downstream faces had special flanges for joining the unit to the flanges of the test apparatus. Near the downstream face, the housing was adapted to receive

*This report is submitted for information only, and is not released for use in connection with advertising or sales promotion.

an afterfilter, which for this unit was a 23 by 21 7/8 by 7/8 inch viscid impingement type air filter (Airsan AF150) manufactured by the Air Filter Corporation of Milwaukee, Wisconsin. The afterfilter had a net face area of 3.03 square feet.

The filter cell of the unit was 24 inches in height, 22 1/16 inches in width, and 17 7/8 inches in length, and contained 63 aluminum plates (32 plates 21 1/4 by 10 3/4 inches, and 31 plates 23 1/16 10 3/4 inches in dimension) spaced about 5/16 inch on centers, presenting a total surface area of approximately 206 square feet. The gross inlet area of the ionizer assembly was 2.57 square feet, and the gross cell transverse area was 3.68 square feet.

The manufacturer furnished an adhesive, designated as EAC-2 "Socony Mobile Par 3000 hot water emulsion type," with which the collector plates were oiled by spraying them from both the upstream and downstream faces. The afterfilter was oiled in preparation for the test by spraying the media from the upstream and downstream sides with the same adhesive.

The power pack, connected to a 110-volt, 60-cycle supply, was adjusted by the manufacturer's representative to recommended settings prior to the tests; the ionizer and plate voltages that resulted were measured by means of an accurate electrostatic voltmeter.

3. TEST METHOD AND PROCEDURE

Efficiency determinations were made by the NBS "Dust-Spot Method" using the following aerosols: (a) outdoor air drawn through the laboratory without addition of other dust or contaminant and (b) Cottrell precipitate. The test method is described in the paper "A Test Method for Air Filters" by R. S. Dill (ASHVE Transactions, Vol. 44, p. 379, 1938). The test duct and arrangement are shown in Figure 1. A baffle made of two 3-inch wide slats was located in the duct about 3 1/2 feet downstream of the test assembly to intermix the air discharged from it.

For these tests, the unit was installed in the test duct and carefully sealed to prevent inleakage of air. The desired rate of air flow through the air cleaner was established and samples of air were drawn from the center points of the test duct one foot upstream and eight feet downstream of the air cleaner assembly at equal rates and passed through known areas of Whatman No. 41 filter paper. For the atmospheric air tests, the samples were drawn at equal rates through equal areas of filter paper (3/4-inch diameter spots). The downstream sample was drawn continuously during the test;

the upstream sample was drawn intermittently in a number of one-minute periods uniformly distributed over the duration of the test, aggregating one-tenth of the downstream sampling period. Under these conditions an efficiency of 90 percent would be indicated if the upstream and downstream dust-spots on the filter papers had the same opacity, as indicated by the change in the light transmissions of the dust-spot areas before and after the sample was drawn, which were determined by means of a photometer using transmitted light. The filter papers used in the upstream and downstream positions were selected to have the same light transmission readings when clean. If the opacities of the dust-spots differed, the efficiency was calculated by means of the formula

$$\text{Efficiency, percent} = 100\left[1 - \frac{t_1}{t_2} \cdot \frac{O_2}{O_1}\right] = 100 - 10\left(\frac{O_2}{O_1}\right)$$

where O_1 and O_2 were the opacities of the dust-spots upstream and downstream, respectively, and t_1 and t_2 were the aggregate times during which the upstream and downstream samples, respectively, were drawn.

For the efficiency tests with Cottrell precipitate as the aerosol, the samples upstream and downstream were drawn at equal rates and for equal times, but unequal dust-spot areas were used to obtain opacities that were approximately equal. If the opacities of the dust-spots differed, the value of the efficiency was calculated by means of the formula above, with the ratio A_2/A_1 substituted for the ratio t_1/t_2, where A_2 and A_1 were the areas of the dust-spots downstream and upstream, respectively.

The following procedure was employed in these tests. After the clean and oiled unit had been installed in the test duct, and all discoverable air leaks into its housing had been sealed, its input and output voltages were adjusted to recommended values by a representative of the manufacturer: (input 110 volts; ionizer 17.4 kv; plates 8.5 kv). Two determinations of the efficiency of the clean unit were made at the rated velocity, using as the aerosol outdoor air drawn into the test duct through a nearby open window. A determination of efficiency with the unit not energized was also made. Following these, single determinations were made, using outdoor air, at air flows 20 percent greater, and 20 percent less than the rated air flow.

Following these, two efficiency determinations were made at the rated air flow, using as an aerosol outdoor air in which was dispersed Cottrell precipitate at a concentration of one gram per thousand cubic feet of air. When these

had been obtained, the process was begun of loading the unit with a mixture of 4 percent cotton lint and 96 percent Cottrell precipitate, by weight, separately dispersed into the air stream. The lint used for this purpose was No. 7 cotton linters previously ground in a Wiley mill with a 4-millimeter screen; the lint was dispersed into the air stream through an aspirator operating at approximately 35 psi inlet air pressure. At suitable periods, as loading progressed, the efficiency of the unit was determined using 100 percent Cottrell precipitate in outdoor air. In these tests, and during the loading process, the rate of feed of the dispersant was one gram per thousand cubic feet of air. The pressure drop and the ionizer and plate voltages of the unit were recorded at intervals during the tests. The dirt-loading process was continued until 1245 grams of the lint and Cottrell precipitate mixture had been fed (i.e., 2/3 gram per cfm of unit rating).

At suitable periods as the dirt-loading process progressed, strips of transparent cellophane adhesive tape (3/4-inch wide) were stretched vertically across the test duct near its axis, with the adhesive side facing upstream. Tapes were located at two positions, (1) 12 inches upstream and (2) 15 inches downstream of the test unit. The adhesive surface of such a tape captured a sample of the particulate matter in the air flowing past it, and after suitable times of exposure to the aerosol, scrutiny of the tapes by eye and with a microscope afforded considerable information as to the vertical distribution, the nature, number, and size of the particles caught at the various stations.

The filter cell was removed from the test unit and cleaned by means of a stream of cold water from a high pressure hose nozzle, directed at and into the cell plates from both ends of the unit. The cleanability of the afterfilter was determined separately, by the same means.

4. TEST RESULTS

A summary of the test data giving efficiencies in percent with the two aerosols and the pressure drop of the complete unit, including the afterfilter, in inch W.G., at several rates of air flow, is given in Table 1. A summary of the test data obtained in the dirt-loading test conducted at 1840 cfm is given in Table 2.

Throughout the tests with atmospheric air, electrical sparking or flashing in the unit audible to the ear occurred, on the average, about two times per hour. However, during

the Cottrell and lint loading test, electrical sparking or flashing occurred intermittently, the frequency increasing from about 10 to 15 times per minute at the start to about 50 to 90 times per minute at the end of the loading test.

5. SUMMARY

A. Performance.

The efficiency of the air cleaner in arresting the particulate matter existent in atmospheric air drawn through the unit varied considerably with the air flow at which it was operated, as shown in Table 1. At the rated air flow (1840 cfm), the average efficiency on atmospheric air was 91.7 percent. The efficiencies are reported to three significant figures obtained from the test data. In reporting thus, however, it is considered desirable to point out that an uncertainty on the order of one or two percent is possible in determining efficiencies.

The efficiency of the unit in arresting Cottrell precipitate, initially at a value of 98.6 percent, as shown in Tables 1 and 2, decreased with dirt-loading to about 95.5 percent, later rising to about 97 percent at the end of the test. The slightly lower values of efficiency were obtained when the ionizer and plate voltages had decreased to 16.2 and 8.1 kv, respectively. At the same time, the ionizer current as indicated by the power pack milliammeter was variable, ranging from 1.4 to 2.5 milliamps. Occasionally throughout the loading test the milliammeter read full scale (10 ma) momentarily, returning to the lower value upon shorting or flashing of the unit. An efficiency determination made with atmospheric air at the end of the dirt-loading test indicated that the unit had an efficiency of 88.6 percent on this aerosol when the unit was heavily laden with dirt.

The greater part of the pressure drop through the complete unit was due to the resistance of the afterfilter. It is noted in Table 2 that in the dirt-loading test, the pressure drop of the complete unit increased by 0.51 inch W.G. for a total load of 1245 grams. Pressure drop measurements made at the conclusion of the dirt loading test showed the pressure drop across the cell to be 0.06 inch W.G., and that across the afterfilter to be 0.68 inch W.G. The rise was due chiefly to an increase in the pressure drop of the afterfilter, as a result of an accumulation of cotton lint and of comparatively large particles of Cottrell precipitate on its media.

B. Cleanability.

The filter was subjected to the cleaning process described under Test Method and Procedure. No difficulty was experienced in thoroughly cleaning the ionizer and collector sections of the unit, using moderate care. The afterfilter was also satisfactorily cleaned using the same procedure.

C. General.

On completion of the dirt-loading test, the unit was removed from the test duct and examined. The ionizer assembly and bars, and the insulators, were coated with a moderate layer of dust and lint. Dirt deposits on the collector plates were heaviest one inch downstream from the upstream edges and on the next three to four inches of the plates, the thickness of the deposits being about 1/32 inch. The heaviest deposits were observed on the negative plates. A continuous but thinner layer of dirt was deposited over the remaining area of the collector plates, extending to the aft edges. There were a few instances of lint bridging between the collector plates near the aft edges near the bottom of the cell.

The upstream face of the afterfilter revealed considerable deposits of lint uniformly deposited over the whole air-passing area. The afterfilter was uniformly darkened by a dust deposit on its upstream face.

The dirt (dust) deposits on the electrostatic unit and on the afterfilter appeared to be well saturated with oil. After the unit had been removed from the test duct, the duct section downstream of the unit was carefully swept out with a fine brush. The amount of material obtained from this sweeping was 0.8 gram.

Cellophane tapes, stretched across the test duct downstream of the filter unit with the adhesive side facing upstream, indicated upon visual and microscopic examination after exposure to the air stream throughout the dirt-loading test, that a few particles up to about 200 microns in size had passed through the unit during the dirt-loading tests. Particles smaller than five microns were observed in quantity by microscopic examination of the downstream filter papers and tapes obtained in tests with both aerosols.

Comparison of the numbers of particles on the upstream and downstream tapes indicated, in an obvious way, a high order of efficiency for the unit in arresting Cottrell precipitate, as is also indicated by the dust spot efficiency

results presented in Table 2. The latter results show a considerably higher efficiency for the unit when Cottrell precipitate was being received in the air stream than when the aerosol was outdoor air. The overall efficiency of the unit on particles of the sizes found in Cottrell precipitate appears therefore to be better than on the finer particles in outdoor air. Nevertheless, the downstream tapes, and the deposits on the afterfilter, showed that a few quite large particles of dust escaped beyond the electrostatic unit. Whether the large particles were passed through the unit because they were not arrested at all, or were caught and later dislodged from the collector plates by electrical sparking, is not known from these tests.

As the downstream tapes indicated, a few large particles of dust passed unarrested through the afterfilter. Assuming that one of the functions of the afterfilter is to arrest as much as possible of the material escaping the electrostatic unit, the arrestance characteristics of the afterfilter are of major importance in determining the presence or absence, in the air leaving the complete unit, of such particulate matter.

Table 1

Air Flow cfm	Inlet Aerosol*	Ionizer Voltage kv	Plate Voltage kv	Output Current ma	Pressure Drop in. W.G.	Duration of Test min.	Efficiency percent
1840	A	0	0	0	0.240	40	4.2**
1840	A	17.4	8.7	2.0	.240	180	91.5
1840	A	17.4	8.5	2.0	.240	220	91.8
1472	A	17.4	8.5	2.0	.160	220	96.2
2208	A	17.2	8.5	2.0	.335	180	85.7
1840	C	17.2	8.4	2.0	.230	11	98.5
1840	C	17.2	8.4	2.0	.232	12	98.6

*A = Particulate matter in atmospheric air at NBS.
C = Cottrell precipitate in atmospheric air (1 gram/1000 cf).

** Since the unit was not energized, the efficiency was chiefly that of the afterfilter.

Table 2

Air Flow cfm	Dirt Load* gram	Ionizer Voltage kv	Plate Voltage kv	Ionizer Current ma	Pressure Drop in. W.G.	Efficiency** percent
1840	37	17.2	8.4	2.0	0.230	98.6(avg.)
	230	17.0	8.4	2.0 to 4.0	.252	98.4
	441	16.2	8.3	1.7 to 3.0	.292	97.9
	632	16.0	7.6	1.5 to 2.3	.345	97.7
	843	16.2	8.1	1.4 to 2.0	.437	95.7
	1074	16.2	8.1	1.6 to 2.5	.590	95.4
	1245	16.5	8.3	1.4 to 2.4	.740	97.1
	1245	16.6	8.4	1.2	.760	88.6(a)

*Average mixture: 4.0 percent lint, 96 percent Cottrell precipitate by weight.

**Efficiency determined with 100 percent Cottrell precipitate.

(a) Efficiency determined with aerosol "A" as in Table 1, with the unit dirty.

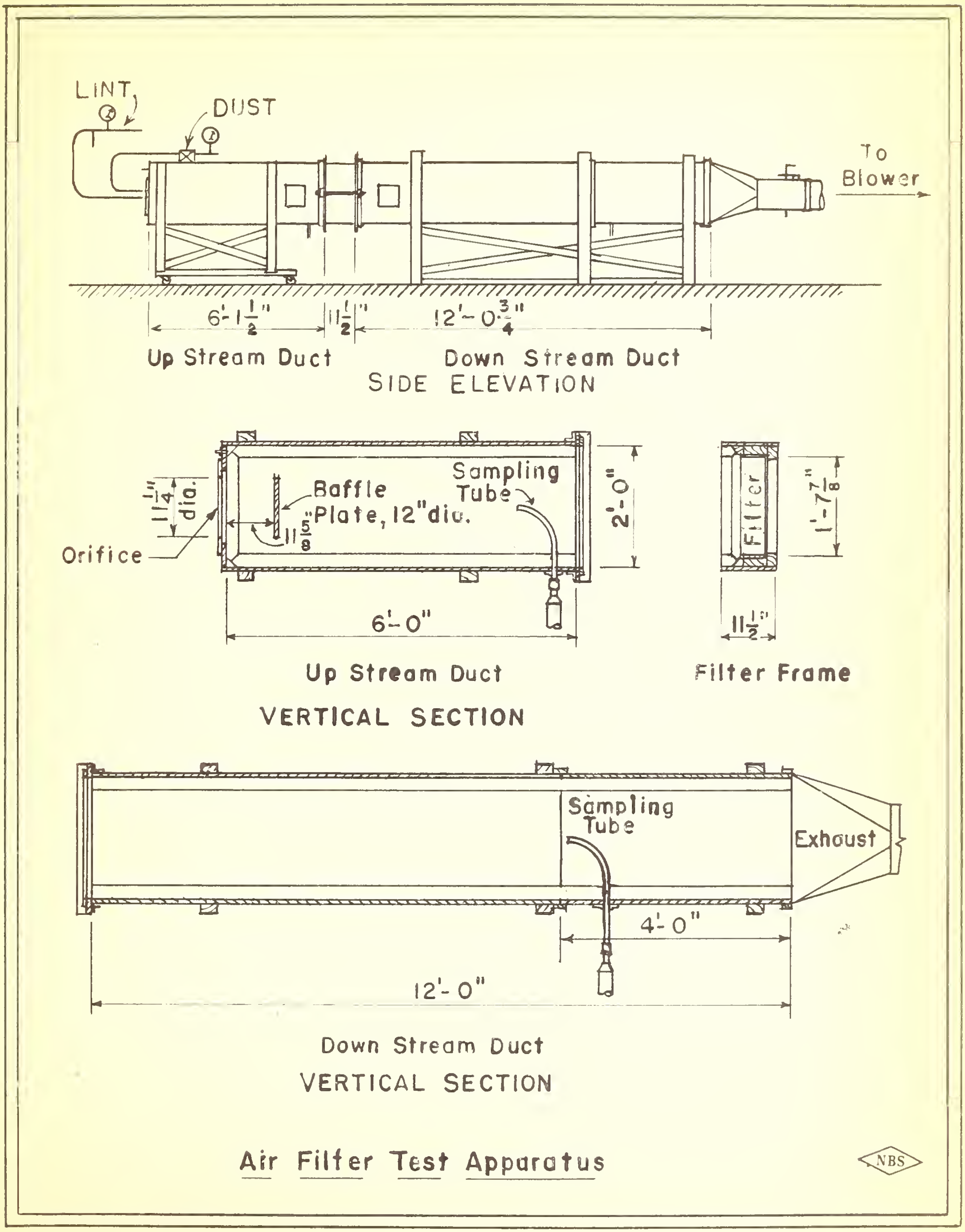
LINT
DUST
To
Blower
6'-1 1/2"
11 1/2"
12'-0 3/4"
Up Stream Duct
Down Stream Duct
SIDE ELEVATION
11 1/4" dia.
Orifice
Baffle Plate, 12" dia.
11 5/8
Sampling Tube
2'-0"
6'-0"
Up Stream Duct
Filter
1'-7 7/8"
11 1/2"
Filter Frame
VERTICAL SECTION
Sampling Tube
Exhaust
4'-0"
12'-0"
Down Stream Duct
VERTICAL SECTION
Air Filter Test Apparatus
NBS

Figure 1

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Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

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